[0033] FIGS. 9A, and 9B are details of a MEMS device that directly forms the Braille dot using a thin film shape memory alloy or piezoelectric element.

[0034] FIGS. 10A, and 10B are details of a MEMS device that directly forms the Braille dot using a thin film shape memory alloy or piezoelectric element.

[0035] FIGS. 11A, 11B, and 11C are the details of an electrostatic MEMS valve.

[0036] FIGS. 12 A, B, C, D, E, F, G, and H are the details of various electrostatic MEMS valve diaphragm designs.

DETAILED DESCRIPTION OF THE INVENTION

[0037] In one embodiment, the present invention is a refreshable Braille display 2 system or a module from such a system comprising a) a plurality of microelectromechanical valves having a top surface and a bottom surface, each microelectromechancial valve having an opening or positioned in line with an opening, each of which represents a Braille dot and each opening arranged in a pattern of Braille cells with the Braille cells forming a Braille display; and b) an elastomeric polymer having a upper and a lower surface, the lower surface of the elastomeric polymer being sealed about each opening which represent the Braille dots; wherein during operation of the display system the upper surface of the elastomeric polymer forms a plurality of Braille dots which are extended and retracted based upon the operation of each of the electromechanical valves. In other embodiments, the refreshable Braille display system uses microelectromechanical piezoelectric devices or microelectromechanical shape memory alloy actuated devices in place of the microelectomechanical valves to deform the elastomeric polymer.

[0038] An example of the refreshable Braille display 2 system of the present invention is shown in FIG. 1. In FIG. 1, a Braille display 2 comprises Braille dots 20 arranged into Braille cells 14. Although, each Braille cell 14 requires only six Braille dots 20, the Braille cell 14 of the present invention is preferably comprised of eight Braille dots 20. The two extra Braille dots 20, (by convention referred to as Braille dots 7 and 8) are used to highlight text within a document such as hyperlinks, boldface or italicized text. The Braille cells 14 are arranged in modules 18. In this embodiment of the present invention, the Braille cells in each module are arranged in two rows and twelve columns (FIG. 2), although other configurations could be used. For pneumatic actuation, a compressor 6 provides pneumatic pressure to the Braille display 2 through tubing 12 or a combined electrical/pneumatic pathway. Optionally, the system can include a pressure vessel along with the compressor 6 or in place of the compressor 6 for pneumatic actuation. The Braille display 2 receives electrical power through power cable 8 which can plug into a standard 120 or 220 volt receptacle or batteries that may be mounted separately or within the Braille display 2. Alternatively, the Braille display may be powered by any means known to those skilled in the art including through a computer data port. In the present embodiment, a data cable 10 connects a personal computer 4 to the Braille display 2.

[0039] Each refreshable Braille display 2 system will be composed preferably of hundreds if not thousands of Braille 20 dots. Preferably, the refreshable Braille display 2 system will be modular in design. This will reduce the costs and provide easy maintenance without sacrificing system robustness. These modules 18 will be able to be stacked both horizontally and vertically for unique versatility in Braille display systems. FIG. 2 is a layout of a module 18 showing Braille cells 14. In FIG. 2 there is shown a layout of a module 18 with the Braille cells 14 arranged in two rows and twelve columns. The present invention is not limited by any particular layout of the modules 18. The module 18, however, is preferably designed to take into account efficiencies in manufacturing both the module 18 and the Braille display 2 as well as Braille display 2 repair and use requirements. Since in this particular embodiment of the present invention, each Braille character comprises eight Braille dots 20, each module 18 will have 2×12×8=192 Braille dots 20. Also, in this particular embodiment (10 rows, 84 cells wide) there are 35 modules 18 on the Braille display 2 arranged in 5 rows and 7 columns for a total number of 6720 Braille dots 20 on the Braille display 2. This modular design allows the production of various sized Braille displays 2 based upon the number of modules 18 used. The modular design allows for longer row (e.g. 10 rows, 84 cells wide) Braille displays to display spreadsheets and other tabular data, or longer and narrower (e.g. 20 rows, 44 cells wide) for reading text, or single module (2 rows, 12 cells wide) Braille displays for use with a portable computer, ATM machines, cell phones, personal digital assistants (PDA's) or other embedded or portable devices.

[0040] FIG. 3 is another embodiment of the module 18. This module 18 contains two Braille cells 14 which contain sixteen Braille dots 20 in total. The schematic shows a further example of how the module 18 and possibly the Braille display 2 (see FIG. 1) could be configured. The module 18 which would be part of an overall Braille display 2 has a plurality of microelectromechanical valves or devices (piezoelectric or shape memory alloy) 16. Each of the microelectromechanical valves or devices 16 having a upper 150 and a lower surface (not shown). The microelectromechancial valves or devices 16 have an opening or are positioned in line with an opening 151 each of which represents a Braille dot 20. The Braille dots 20 are arranged in a pattern of Braille cells 14 and ultimately (through the use of a number of modules 18) form a Braille display 2 (see FIG. 1). The module 18 with an elastomeric polymer 152 (in this example in the form of a thin film) having an upper 153 and a lower surface (not shown). The lower surface of the elastomeric polymer 152 being above the top surface 150 of each of the microelectromechanical valves or devices 16. The elastomeric polymer further being sealed (not shown) on the lower surface about each of the openings 151 which represent the Braille dots 20. The seal about each opening can be made for example using either a suitable epoxy, other adhesive, direct welding or a vacuum seal. During operation of the Braille display 2, the upper surface 153 of the elastomeric polymer 152 forms a plurality of Braille dots 20, which are extended and retracted based on the operation of the microelectromechanical valves or devices 16.

[0041] The Braille dot 20 of the present invention is formed by the deformation of a flexible, compliant and resilient polymer. The flexible, compliant surface 153 may be constructed of a single sheet of polymer material stretched over the top of the housing (not shown) for the Braille display 2 containing a determined compliment of